



KEYLESS ENTRY SYSTEM USING AN MC146805F2()1 8-BIT MICROCOMPUTER UNIT

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INTRODUCTION

The MC146805F2()1 is a single-chip microcomputer unit (MCU) containing 64 bytes of user RAM, 1089 bytes of user ROM, 191 bytes of self-check ROM, 16 bidirectional I/O lines, four input-only lines, two timer registers, and an on-chip oscillator. The MC146805F2()1 contains three distinct program modules, including:

1. Monitor
2. Demonstration Program (Keyless Entry System)
3. Self-Check Program (Self Test)

The self-check feature is fully described in the MC146805F2 data sheet and it can be used to verify operation of the MCU. The self-check routine is included in all MC146805F2 devices.

The monitor routine which is contained in all MC146805F2()1 MCUs is not discussed as part of this application note. The monitor routine allows the user to evaluate the MCU using a standard RS-232 terminal. A copy of the keyless entry demonstration program listing is shown in Figure 2.

KEYLESS ENTRY SYSTEM

NOTICE

The keyless entry system using the MC146805F2()1 8-bit microcomputer unit is not intended to be used by itself in a secure entry system. It is intended to be used only as an aid in better understanding the MC146805F2 MCU and how it can fit into a secure entry system.

The keyless entry system (referred to as a digital lock) is a dedicated MC146805F2()1 MCU, executing a program, that can control a larger configuration to form a security entry system. Figure 1 contains a schematic diagram of the digital lock complete with keypad and liquid crystal display.

The function of the digital lock is to accept inputs from a 3×4 keypad and, if the inputs are in the correctly coded sequence, generate an output which indicates the lock is open. However, if the input code sequence is not entered correctly, the digital lock MCU provides an alarm indication (logic 1) on pin 20 (PB2).

The user interfaces with the digital lock MCU through a 3×4 keypad and a wake-up push button. This allows multiple users to gain access to a secure area without the necessity of carrying a key. The LCD displays a dash for each keypad entry. This ensures that the user knows how many of the required keypad entries have been made.

The digital lock MCU has a feature which protects against trial-and-error attempts to gain entry. If two incorrect code combinations are entered, an alarm output is generated (PB2 goes high). The alarm condition remains active until the combination is entered or power is disconnected.

Once the correct combination has been entered via the keypad, the LCD spells out the word OPEN. From this time, the user has eight seconds to open the door or other locked device.

INITIALIZATION

When power is initially applied or if power is lost and then reapplied, the 8-digit combination code is lost in RAM. It now becomes necessary to enter a new 8-digit combination. This can be done by performing the procedure outlined in the Changing The Combination paragraph.

OPERATION

Two operating modes are described below. One is the normal user procedure to open the lock and the other describes a method to change the combination.

Opening The Lock

To open the lock:

1. Press the wake-up push button and check that the LCD is clear.

2. Use the keypad to enter the 8-digit change combination code number 14680502. Note that each time a keypad switch is depressed, a dash will appear on the LCD to indicate that a digit is entered. Once all eight digits are entered the LCD goes blank.
3. Use the keypad to enter the new 8-digit combination code. As before, a dash appears each time a keypad switch is depressed.
4. Once the eight new digits are entered, the word VERIFY appears on the LCD. This is a prompt for the user to enter the same 8-digit combination code as in 3 above. If the second 8-digit entry is not exactly the same as the first, the word ERROR is displayed on the LCD. In this case, the user must repeat the procedure from 3 above.

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MC146805F2L1 EVALUATION ROM (C) MOTOROLA 1982

```

00639      *
00640      *
00641      *
00642      *****
00643      *
00644      *   OPTIONAL PROGRAM
00645      *****
00646      *
00647      *
00648      *****
00649      *
00650      *   THIS IS THE MC146805F2 DEMO PROGRAM. IT IS A KEYLESS ENTRY S
00651      *   THAT SCANS A MATRIX OF KEYS FOR A SET OF EIGHT NUMBERS THAT FORMS
00652      *   CODE TO ENTER OR TO CHANGE THE ENTRY CODE. IF AFTER TWO WRONG EN
00653      *   AN ALARM WILL GO OFF. IF AFTER A PERIOD OF TIME THERE IS NO RESP
00654      *   TO THE SYSTEM IT WILL SHUT ITSELF OFF USING THE 'F2' STOP INSTRU
00655      *
00656      *
00657      *
00658      *
00659      *   BY MICHAEL G. GALLUP AND VERNON GOLER
00660      *   9/09/81
00661      *****
00662      *
00663      *
00664      *   THIS IS THE EQUATE SECTION
00665      *
00666      *
00667      *
00668A 0040      *   ORG   $40
00669      *
00670      *
00671A 0040      *   A CTRL FCB 0
00672A 0041      *   A CODE RMB 8   ENTRY CODE LOCATION
00673A 0049      *   A NCODE RMB 8   ENTERED CODE LOCATION
00674A 0051      *   A VERI RMB 8   VERIFY CODE LOCATION
00675A 0059      *   A TEMPX FCB 0   TEMPORARY REG FOR X
00676A 005A      *   A TEMP FCB 0   ANOTHER TEMP REG
00677A 005B      *   A TEMP2 FCB 0   TIME COUNTER (UPPER)
00678A 005C      *   A TEMP1 FCB 0   TIME COUNTER (LOWER)
00679A 005D      *   A TEMPAL FCB 0   TIME DELAY REGISTER
00680A 005E      *   A TEMPB FCB 0
00681A 005F      *   A VALID1 FCB 0
00682A 0060      *   A VALID2 FCB 0
00683A 0061      *   A TEMP3 FCB 0
00684      *
00685      *
00686      *   A BLANK EQU $00   BLANK CHARATER TO LCD
00687      *   A DASH EQU $20   DASH
00688      *
00689A 0343      *   ORG   $343
00690      *
00691      *   INITIALIZATION GOES HERE
00692      *
00693A 0343 A6 F0      *   A LOCK LDA  #F0
00694A 0345 B7 04      *   A STA  PORTA+DDR
00695A 0347 3F 01      *   A CLR  PORTB   CLEAR PORTB
00696A 0349 3F 40      *   A CLR  CTRL

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FIGURE 2 — Keyless Entry System Program

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MC146805F2L1 EVALUATION ROM (C) MOTOROLA 1982

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00697A 034B 4F          CLRA
00698A 034C 43          COMA          GET FF
00699A 034D B7 05      A          STA          PORTB+DDR SET PORTB DDR TO OUTPUT
00700A 034F CD 0484    A BEGIN  JSR          CLEAR
00701          *
00702          *
00703A 0352 8E          STOP          STOP PROCESSOR AND WAIT
00704A 0353 CD 0484    A BGIN1  JSR          CLEAR          CLEAR DISPLAY
00705A 0356 9A          CLI
00706          *
00707          *
00708          * GET NUMBER
00709          *
00710A 0357 AE 49      A          LDX          #NCODE          GET RAM SORAGE SPOT
00711A 0359 AD 76      03D1     BSR          GET8          GET 8 NUMBERS
00712          *
00713          * NOW THAT WE HAVE THE EIGHT DIGIT NUMBER COMPARE IT TO
00714          * THE VALID ENTRY CODE AND THE CHANGE CODE. IF THERE IS
00715          * NO MATCH INCREMENT ALARM COUNTER.
00716          *
00717A 035B AE 08      A          LDX          #$08          GET COUNT
00718A 035D E6 48      A MOR2    LDA          NCODE-1,X GET FIRST/N NUMBER
00719A 035F E1 D0      A          CMP          CHG-1,X IS IT THE CHANGE CODE?
00720A 0361 26 05      0368     BNE          MORR          IF Z=0 NOT EQUAL
00721A 0363 5A          DECX          DECREMENT COUNTER
00722A 0364 26 F7      035D     BNE          MOR2          DO MORE IF NO
00723A 0366 20 0A      0372     BRA          VERI1
00724          *
00725          *
00726A 0368 AE 41      A MORR    LDX          #CODE          GET FIRST LOCATION
00727A 036A CD 048D    A          JSR          BLCMP          COMPARE THEM
00728A 036D 4C          INCA          CHECK FOR EQUAL
00729A 036E 26 37      03A7     BNE          OPEN          IF NOT 0 THEN EQUAL
00730A 0370 20 55      03C7     BRA          ALARM1
00731          *
00732          *
00733          *
00734          * CHANGE ENTRY CODE SECTION WITH VERIFY
00735          *
00736A 0372 CD 0484    A VERI1  JSR          CLEAR          CLEAR DISPLAY
00737A 0375 AE 49      A VERI2  LDX          #NCODE          GET RAM LOCATION
00738A 0377 AD 58      03D1     BSR          GET8          GET NUMBER
00739          *
00740          *
00741          * SEND THE WORD VERIFY HERE
00742          *
00743A 0379 AE 08      A          LDX          #$08          GET COUNTER
00744A 037B E6 B8      A LOOP    LDA          VERIFY-1,X
00745A 037D CD 046C    A          JSR          DSPLY
00746A 0380 5A          DECX          DECREMENT COUNTER
00747A 0381 26 F8      037B     BNE          LOOP
00748          *
00749          *
00750          *
00751          *
00752A 0383 AE 51      A          LDX          #VERI          GET RAM LOCATION
00753A 0385 AD 4A      03D1     BSR          GET8          GET NUMBER
00754          *

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FIGURE 2 — Keyless Entry System Program (continued)

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00755      *      COMPARE VERIFY
00756      *
00757A 0387 AE 49      A      LDX      #NCODE      GET FIRST NUMBER
00758A 0389 CD 048D    A      JSR      BLCMP      COMPARE
00759A 038C 4C        A      INCA      CHECK FOR FF
00760A 038D 27 0C      039B    BEQ      CNT2      IF ZERO THEN ERROR
00761      *
00762      *      VERIFY OK
00763      *
00764      *
00765      *
00766      *
00767      *
00768      *
00769A 038F AE 08      A      LDX      #$08
00770A 0391 E6 50      A MOR6    LDA      VERI-1,X GET START OF CODE
00771A 0393 E7 40      A      STA      CODE-1,X STORE IT
00772A 0395 5A        A      DECX
00773A 0396 26 F9      0391    BNE      MOR6      IF NOT DONE DO MOR6
00774A 0398 CC 034F    A      JMP      BEGIN      GOTO START OF PROGRAM
00775      *
00776      *      IF IT GETS HERE THERE HAS BEEN A VERIFY ERROR
00777      *      SEND THE WORD ERROR TO THE LCD
00778      *
00779A 039B AE 08      A CNT2    LDX      #$08      GET COUNTER
00780A 039D E6 C0      A LOOP2   LDA      ERROR-1,X
00781A 039F CD 046C    A      JSR      DSPLY
00782A 03A2 5A        A      DECX
00783A 03A3 26 F8      039D    BNE      LOOP2
00784A 03A5 20 CE      0375    BRA      VERI2
00785      *
00786      *      THIS IS THE OPEN LOCK PART
00787      *
00788A 03A7 AE 08      A OPEN    LDX      #$08      GET COUNTER
00789A 03A9 E6 C8      A LOO3   LDA      OPEN1-1,X
00790A 03AB CD 046C    A      JSR      DSPLY
00791A 03AE 5A        A      DECX
00792A 03AF 26 F8      03A9    BNE      LOO3
00793      *
00794A 03B1 0F 40 04 03B8 BRCLR   7,CTRL,NXT ALARM BIT SET?
00795A 03B4 1F 40      A      BCLR   7,CTRL RESET IF YES
00796A 03B6 15 01      A      BCLR   2,PORTB CLEAR ALARM BIT TO OUTSIDE
00797A 03B8 A6 F8      A NXT     LDA      #$F8
00798A 03BA B7 01      A      STA      PORTB
00799      *
00800      *
00801      *
00802      *      LOOP FOR APPROX. 8 SECONDS
00803      *
00804      *
00805A 03BC AE FF      A      LDX      #$FF      GET COUNT
00806A 03BE CD 04A1    A      JSR      TMDLY      DELAY
00807      *
00808      *
00809      *      CLOSE LOCK
00810      *
00811A 03C1 4F        A      CLRA
00812A 03C2 B7 01      A      STA      PORTB

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FIGURE 2 — Keyless Entry System Program (continued)

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00813 *
00814 *
00815 *
00816A 03C4 CC 034F A JMP BEGIN
00817 *
00818 * THIS IS THE ALARM SPOT
00819 *
00820A 03C7 3C 40 A ALARM1 INC CTRL INCREMENT ALARM COUNTER
00821A 03C9 03 40 02 03CE BRCLR 1,CTRL,NXT2 CHECK FOR ALARM=2
00822A 03CC 14 01 A BSET 2,PORTB IF ALARM=2 THEN SET BIT
00823A 03CE CC 034F A NXT2 JMP BEGIN GOTO START
00824 *
00825 *
00826 *
00827 * THIS IS THE SUBROUTINE GET8
00828 *
00829A 03D1 A6 08 A GET8 LDA #$08 GET NUMBER COUNT
00830A 03D3 B7 5C A STA TEMP1 SAVE COUNTER
00831A 03D5 A6 40 A SCAN2 LDA #$40 GET UPPER COUNTER
00832A 03D7 B7 5B A STA TEMP2 SAVE COUNTER
00833A 03D9 A6 FF A SCAN1 LDA #$FF GET LOWER COUNTER
00834A 03DB B7 5A A STA TEMP SAVE COUNTER
00835 *
00836 *
00837 *
00838 *****
00839 * THIS SUBROUTINE SCANS A 4 X 3 MATRIX OF KEYS AND RETURNS A *
00840 * VALUE OF 1-12 IN THE A ACCUMULATOR IF IT FINDS ONE DEPRESSED, *
00841 * OTHERWISE IT RETURNS A VALUE OF $FF IF NO KEY IS DEPRESSED. THE *
00842 * ONLY REGISTER DESTROYED IS THE A ACCUMULATOR ALL OTHER REGISTERS *
00843 * ARE LEFT ALONE. *
00844 *****
00845 *
00846 *
00847 *
00848 *
00849 *
00850 *
00851 A SCAN EQU *
00852A 03DD A6 40 A LDA #$40
00853A 03DF B7 00 A STA PORTA SELECT ONE COLUMN AT A TIME
00854A 03E1 BF 59 A STX TEMPX SAVE X REGISTER
00855A 03E3 AE 03 A LDX #$03 COUNT THE COLUMN
00856 *
00857 *
00858 *
00859A 03E5 B6 00 A LOOPA LDA PORTA CHECK IF KEY PRESSED, ONE COL AT A TIME
00860A 03E7 A4 0F A AND #$0F CLEAR UPPER NIBBLE
00861A 03E9 26 23 040E A BNE DEBNCE BRANCH IF KEY PRESSED
00862A 03EB 34 00 A NOKEY LSR PORTA NEXT COLUMN
00863A 03ED 5A DECX DECREMENT COLUMN COUNT
00864A 03EE 26 F5 03E5 A BNE LOOPA NO KEY PRESSED
00865A 03F0 5A DECX RETURN X WITH $FF
00866 *
00867 *
00868 *
00869A 03F1 9F EXIT TXA
00870A 03F2 BE 59 A LDX TEMPX

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FIGURE 2 — Keyless Entry System Program (continued)

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00871A 03F4 20 4D 0443 BRA CK
00872 *
00873 *
00874 *
00875A 03F6 44 FOUND LSRA SHIFT IF THE ROW INFO 1 PLACE
00876A 03F7 25 05 03FE BCS CHECK ADD 3 FOR EVERY ROW
00877A 03F9 5C INCX
00878A 03FA 5C INCX
00879A 03FB 5C INCX
00880A 03FC 20 F8 03F6 BRA FOUND
00881 *
00882 *
00883 *
00884A 03FE A3 0A A CHECK CPX #00A
00885A 0400 25 EF 03F1 BLO EXIT NUMBER RETURNED < 10
00886A 0402 A3 0B A CPX #00B
00887A 0404 27 04 040A BEQ FIX INPUT NUMBER IS ZERO
00888A 0406 AE FF A INVAL LDX #FFF INVALID ENTRY RETURN $FF
00889A 0408 20 E7 03F1 BRA EXIT
00890A 040A AE 00 A FIX LDX #000 RETURN 0 IN X
00891A 040C 20 E3 03F1 BRA EXIT
00892 *
00893 *
00894 *
00895A 040E B7 5E A DEBNCE STA TEMPA SAVE A REGISTER
00896A 0410 3F 5F A CLR VALID1
00897A 0412 3F 60 A CLR VALID2
00898A 0414 44 DBNCE1 LSRA
00899A 0415 25 04 041B BCS ONEKEY CHECK TO MAKE SURE ONLY ONE KEY PRESSED
00900A 0417 3C 5F A INC VALID1
00901A 0419 20 F9 0414 BRA DBNCE1 CONTINUE CHECK
00902A 041B A1 00 A ONEKEY CMP #000 ONLY ONE KEY PRESSED
00903A 041D 26 E7 0406 BNE INVAL NO, MORE THAN ONE KEY PRESSED
00904 *
00905 *
00906A 041F BF 61 A STX TEMP3
00907A 0421 AE FF A LDX #FFF
00908A 0423 5A MOR10 DECX
00909A 0424 26 FD 0423 BNE MOR10
00910A 0426 BE 61 A LDX TEMP3
00911 *
00912A 0428 B6 00 A LDA PORTA CHECK TO MAKE SURE ORIGINAL KEY PRESSED
00913A 042A A4 0F A AND #00F
00914A 042C 44 ROWCK1 LSRA
00915A 042D 25 04 0433 BCS ONEKY1
00916A 042F 3C 60 A INC VALID2
00917A 0431 20 F9 042C BRA ROWCK1
00918A 0433 B6 60 A ONEKY1 LDA VALID2
00919A 0435 B1 5F A CMP VALID1 SAME KEY PRESSED
00920A 0437 26 CD 0406 BNE INVAL NO! SAME KEY NOT PRESSED
00921 *
00922 *
00923 *
00924A 0439 B6 00 A UPKEY LDA PORTA CHECK TO MAKE SURE KEY HAS BEEN RELEASED
00925A 043B A4 0F A AND #00F
00926A 043D 26 FA 0439 BNE UPKEY RELEASED? NO
00927A 043F B6 5E A LDA TEMPA VALID KEY PRESS
00928A 0441 20 B3 03F6 BRA FOUND CALCULATE KEY NUMBER

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FIGURE 2 — Keyless Entry System Program (continued)

MC146805F2L1 EVALUATION ROM (C) MOTOROLA 1982

```

01045      *
01046      *
01047      *
01048      *
01049      *
01050      *
01051      *****
01052      *
01053      *   VECTORS
01054      *
01055      *****
01056A 07F6      ORG      MEMSIZ-10
01057A 07F6      0353      A      FDB      BGIN1
01058A 07F8      0353      A      FDB      BGIN1
01059A 07FA      04B2      A      FDB      INT
01060A 07FC      0179      A      FDB      MONIT      SWI
01061A 07FE      00F8      A      FDB      RESET

```

FIGURE 2 — Keyless Entry System Program (concluded)

OUT OF SEQUENCE

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MC146805F2L1 EVALUATION ROM (C) MOTOROLA 1982

```

00929
00930
00931
00932
00933
00934
00935
00936
00937
00938
00939
00940A 0443 4C      CK      INCA      INCREMENT A Z=1=NOKEY
00941A 0444 26 17    045D    BNE      BACK      GO BACK IF NOT ZERO
00942A 0446 BF 59      A      STX      TEMPX     SAVE X
00943A 0448 AE 01      A      LD      #01
00944A 044A AD 55    04A1    BSR      TMDLY     DELAY FOR 32MS
00945A 044C BE 59      A      LD      TEMPX     GET X
00946A 044E 3A 5A      A      DEC      TEMP      DEC LOWER COUNTER
00947A 0450 26 8B    03DD    BNE      SCAN      CHECK FOR MORE KEYS
00948A 0452 3A 5B      A      DEC      TEMP2     DEC UPPER COUNTER
00949A 0454 26 83    03D9    BNE      SCAN1     CHECK FOR MORE KEYS
00950
00951
00952
00953A 0456 CD 0484    A BCK     JSR      CLEAR
00954A 0459 9C
00955A 045A CC 034F    A      JMP      BEGIN
00956A 045D 4A      BACK     DECA      ADJUST KEY NUMBER
00957A 045E F7      STA      ,X      SAVE NUMBER
00958A 045F A6 20      A      LDA      #DASH
00959A 0461 AD 09    046C    BSR      DSPLY
00960A 0463 5C      INCX
00961A 0464 3A 5C      A      DEC      TEMP1     INC POINTER
00962A 0466 26 01    0469    BNE      SC1      DEC COUNTER
00963A 0468 81      RTS      IF NOT 8 GET MORE
00964A 0469 CC 03D5    A SC1     JMP      SCAN2     RETURN
00965
00966
00967
00968
00969A 046C BF 59      A DSPLY   STX      TEMPX     SAVE X
00970A 046E AE 08      A      LD      #08      GET COUNTER
00971A 0470 98      CLC      CLEAR CARRY
00972A 0471 48      MOR8     LSLA      ROTATE TO GET BIT
00973A 0472 25 04    0478    BLO      ONE      ONE OR A ZERO
00974A 0474 11 01      A      BCLR     0,PORTB  SEND ZERO
00975A 0476 20 02    047A    BRA      STRB
00976A 0478 10 01      A ONE     BSET     0,PORTB  SEND ONE
00977A 047A 12 01      A STRB    BSET     1,PORTB  SEND STROBE
00978A 047C 13 01      A      BCLR     1,PORTB  TO ENTER DATA
00979A 047E 5A      DECX     DEC COUNTER
00980A 047F 26 F0    0471    BNE      MOR8
00981A 0481 BE 59      A      LD      TEMPX
00982A 0483 81      RTS      RETURN
00983
00984A 0484 4F      CLEAR   CLRA
00985A 0485 AE 08      A      LD      #08
00986A 0487 AD E3    046C    LOO      BSR      DSPLY

```

FIGURE 2 — Keyless Entry System Program (continued)

